Electronic Supplementary information (ESI)

Structural designing of Zn_2SiO_4:Mn nanocrystals by co-doping of alkali metal ions in mesoporous silica channels for enhanced emission efficiency with short decay time

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Characterization techniques:

Formation of Zn_2SiO_4:Mn,(Li^+, Na^+, K^+) crystals were confirmed by x-ray diffraction (XRD) [RIGAKU, Ultima IV] using Cu-Ka radiation. Scanning transmission electron microscopy (STEM) measurement was performed using Techni G^2 at 200 keV. Information about the bonding states and elemental composition were extracted from x-ray photoemission spectroscopy (XPS) [Perkin-Elmer, 04-500 dual anode x-ray source instrument]. Before recording the XPS data, sample surface was etched by using low energy argon ion gun to remove the surface contaminations. Morphologies of the samples were investigated using scanning electron microscopy (SEM) equipped with EDS [JEOL, JSM-5900 LVS]. Photoluminescence (PL) spectra and decay profiles were recorded using Hitachi F-4500 fluorescence spectrometer. Quantum efficiency of undoped and K^+ ions doped samples were measured using QE-1100 [Otsuka Electronics] at excitation wavelength 254 nm and 425 nm. All the measurements were performed at room temperature. Standard green phosphor from Kasei Optonix Ltd. Japan was used to compare the performance of the phosphor presented in this work.

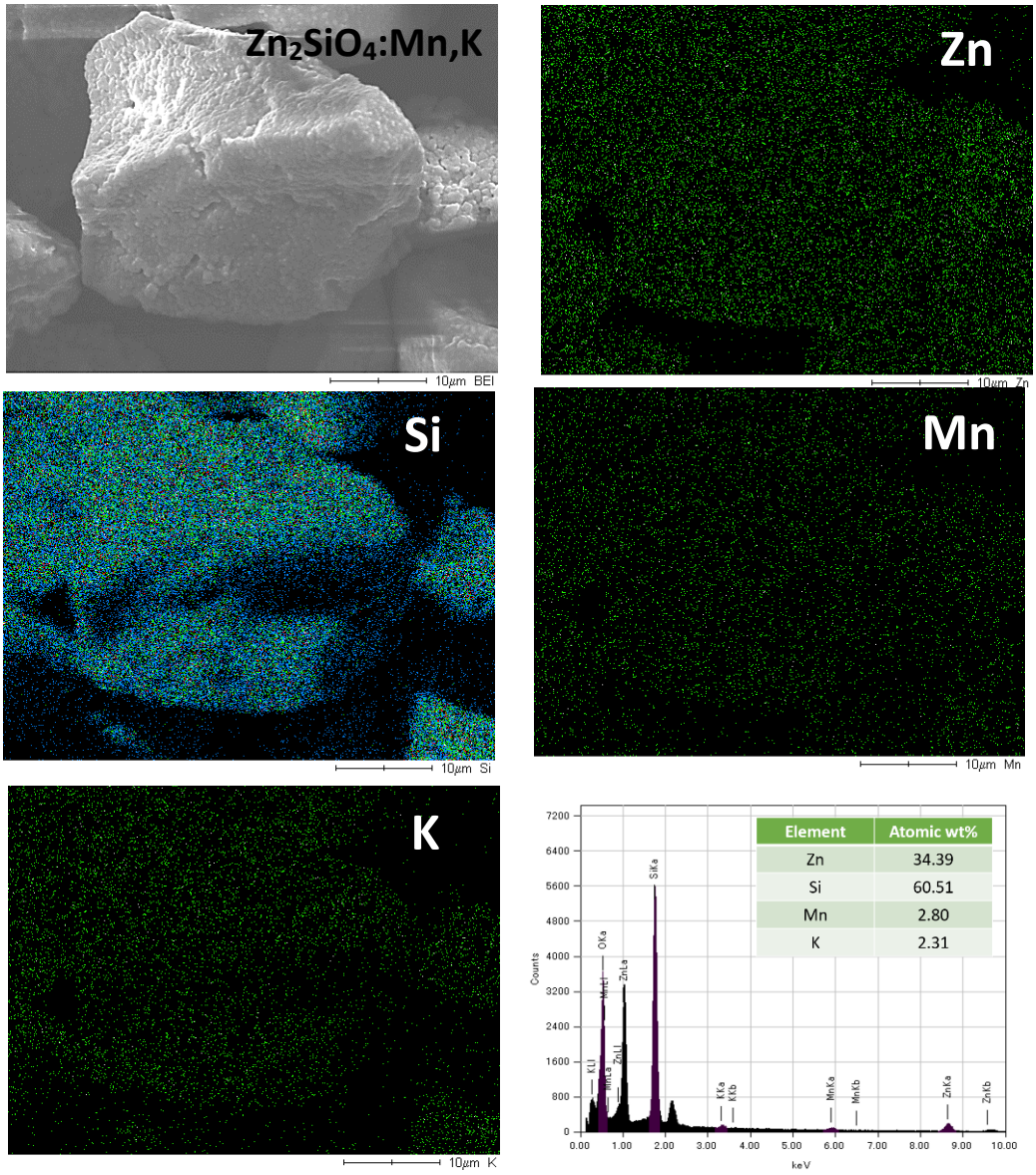


Figure S1: EDX elemental mapping of Zn_2SiO_4:Mn,K crystal synthesized in this work.

Table S1: Elemental distribution of Zn_2SiO_4:Mn crystal doped with 0.30 M of Li^+, K^+ and Na^+ ions, estimated from x-ray photoemission spectroscopy (XPS).

Sample/Element	Zn	Si	O	Mn	Metal ion
Undoped	7.66	23.97	67.63	0.74	none
Zn_2SiO_4:Mn, Li-doped_0.30M	5.8	23.68	68.14	0.91	1.46 (Li^+)
Zn_2SiO_4:Mn, K-doped_0.30M	8.67	22.05	65.42	1.4	2.45 (Na^+)
Zn_2SiO_4:Mn,,Na-doped_0.30M	9.03	19.78	61.60	1.29	8.3 (K^+)

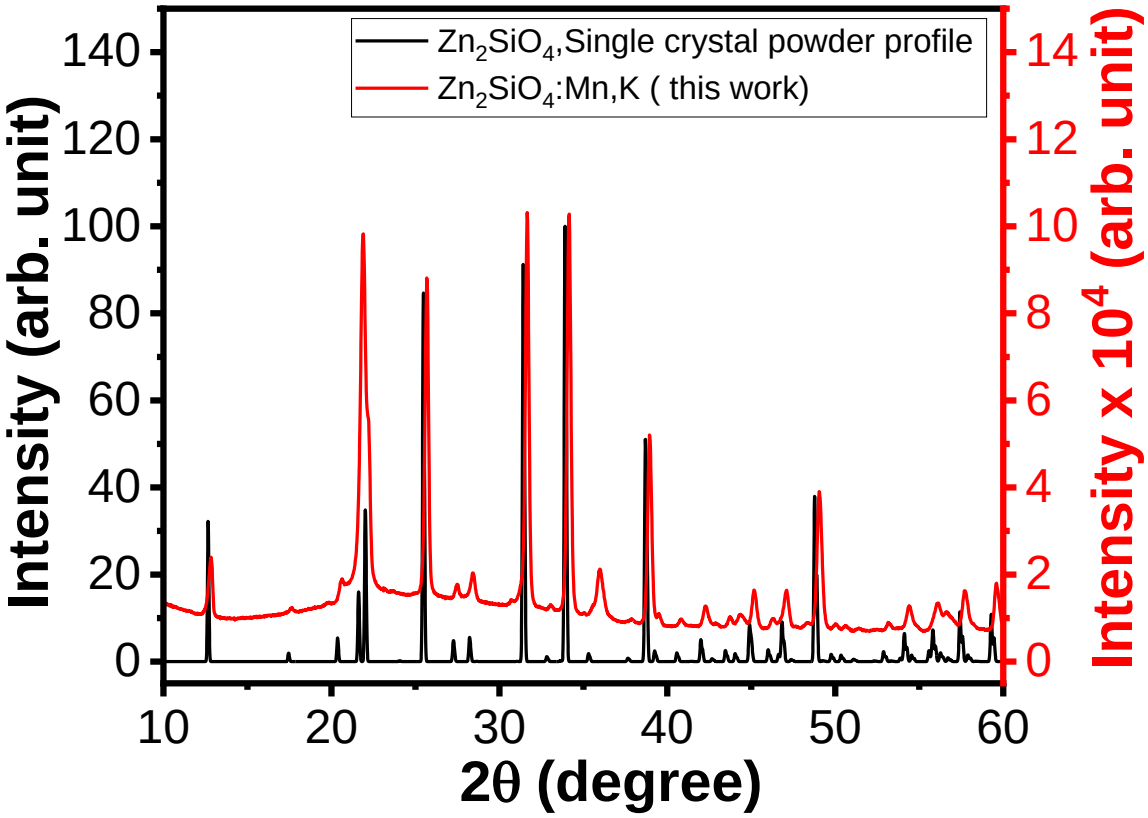


Figure S2: Comparison of Zn_2SiO_4 single crystal XRD and K^+ ions doped Zn_2SiO_4:Mn phosphor synthesized in this work.

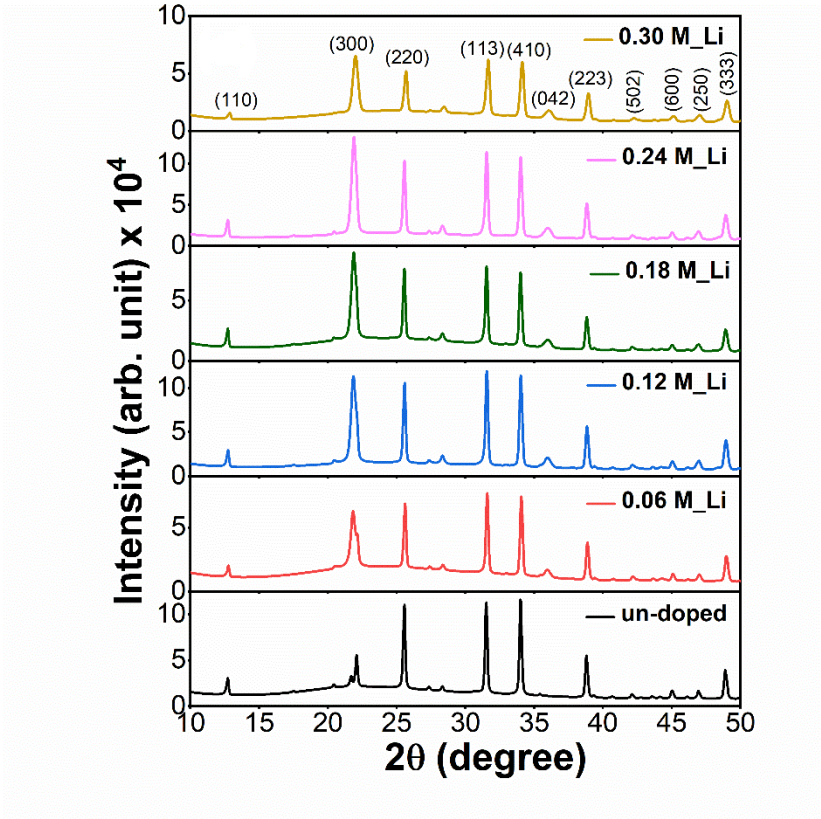


Figure S3: XRD patterns of Li^{+} ions doped Zn_2SiO_4:Mn phosphor.

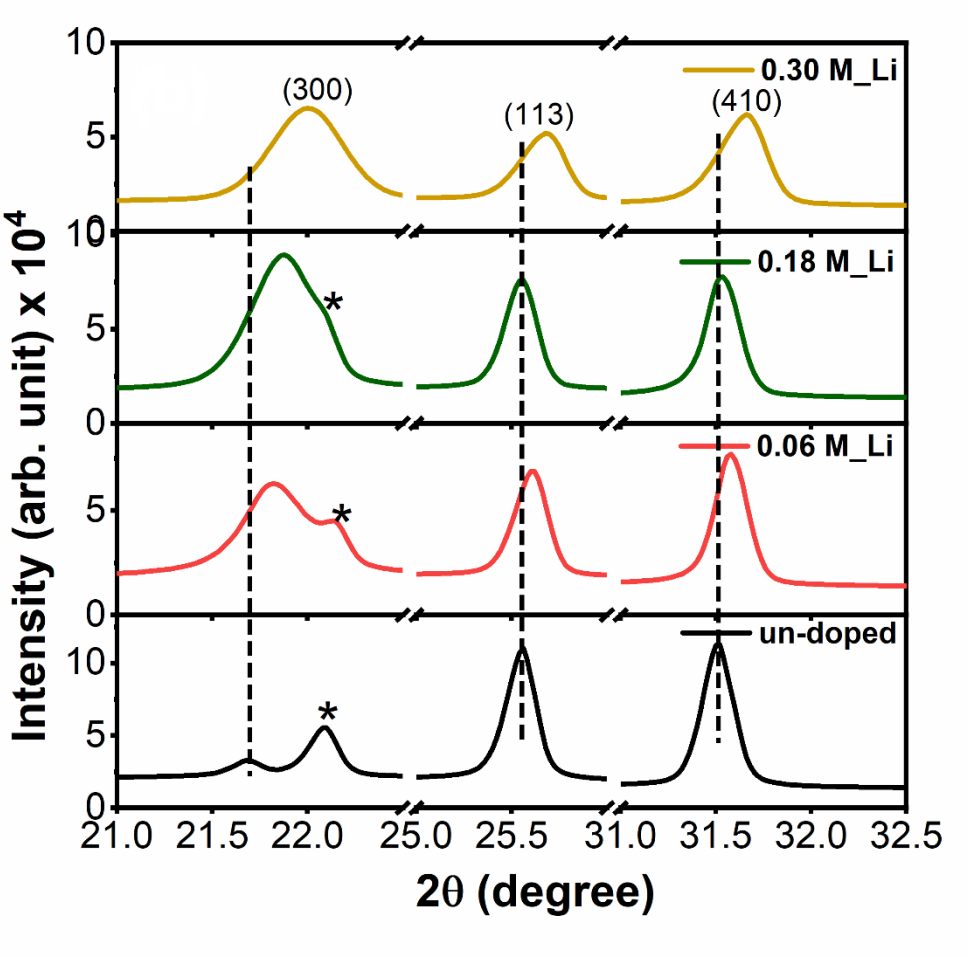


Figure S4: Extended XRD patterns (2θ range 20-40°) of Li^+ ions doped Zn_2SiO_4:Mn phosphor.

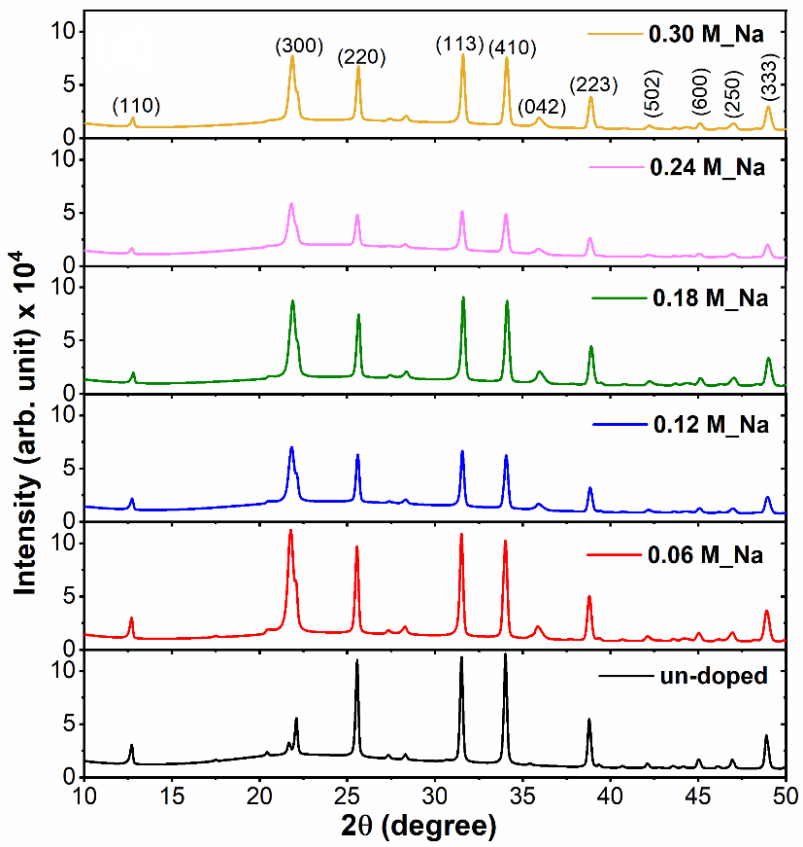


Figure S5: XRD patterns of Na^+ ions doped Zn_2SiO_4:Mn phosphor

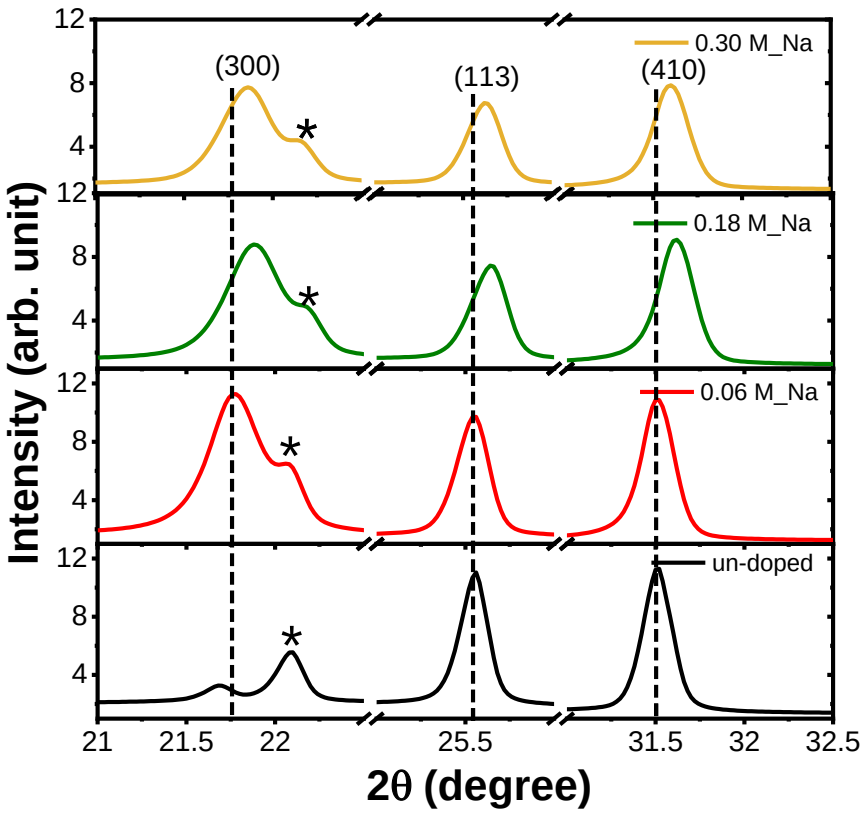


Figure S6: Extended XRD patterns (2θ range 20-40°) of Na^+ ions doped Zn_2SiO_4:Mn phosphor.

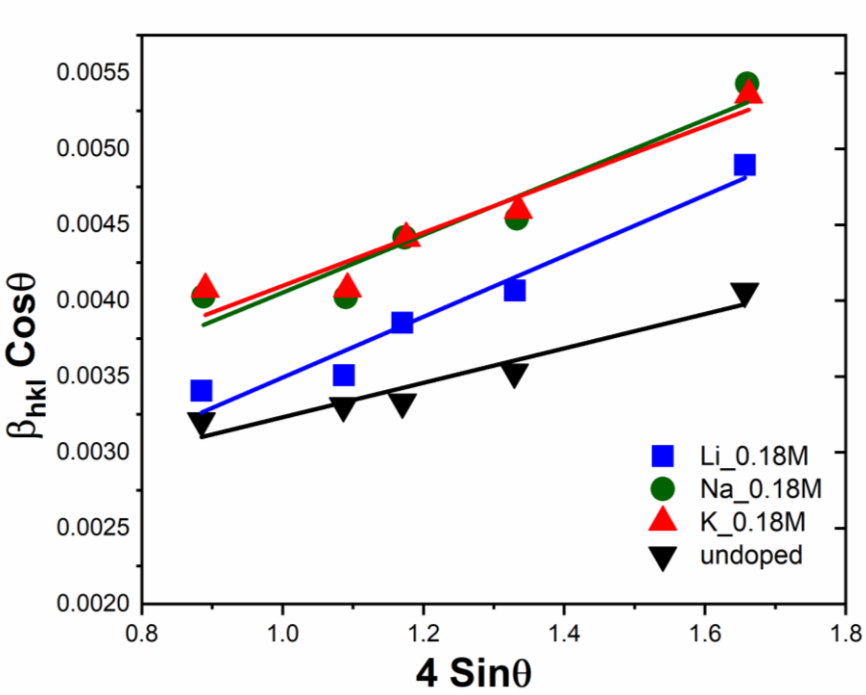


Figure S7: W-H plot for un-doped and doped Zn_2SiO_4:Mn,(Li^+, Na^+, K^+) phosphor at doping concentration of 0.18 M.

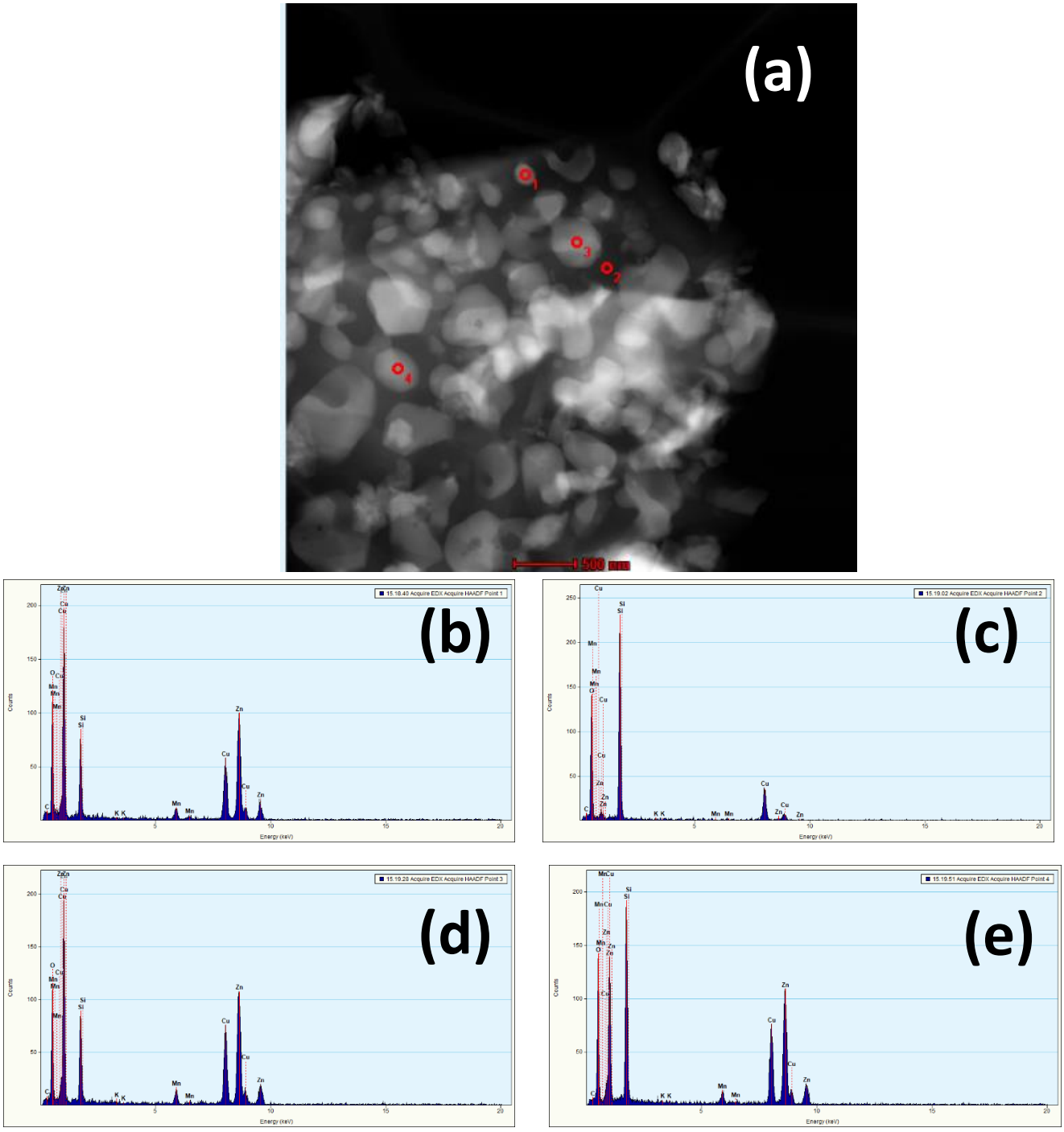


Figure S8: (a) STEM image of K^+ ions doped Zn_2SiO_4:Mn phosphor (b) Elements profiling at point 1, (c) Elements profiling at point 2, (d) Elements profiling at point 3, (e) Elements profiling at point 4.

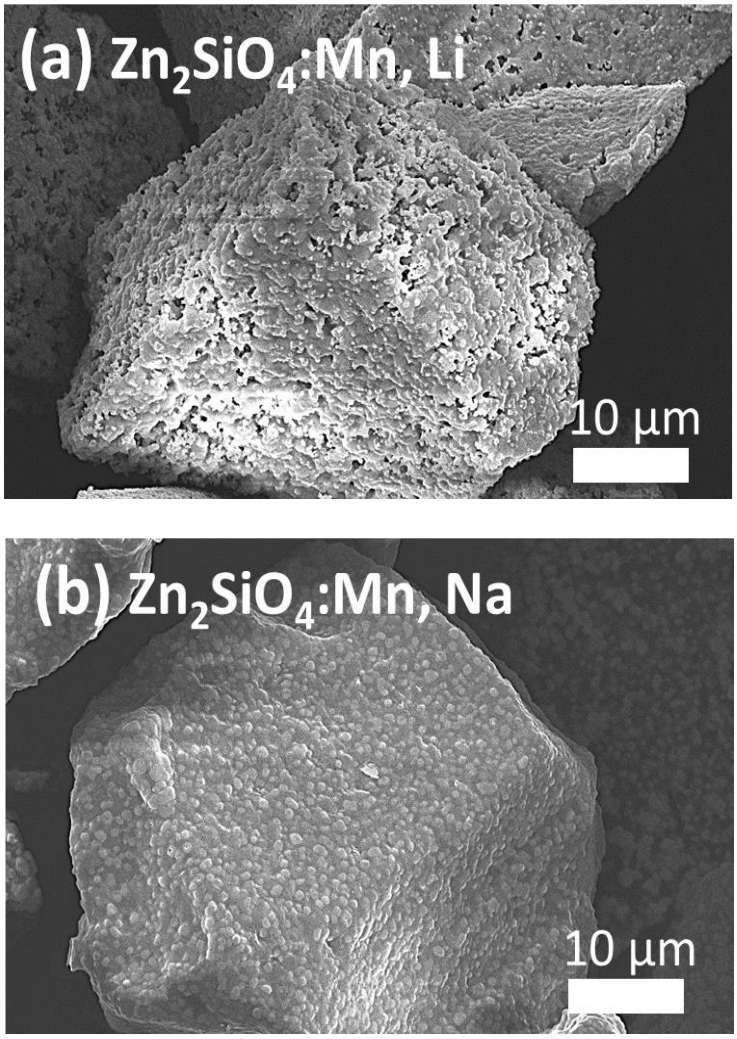
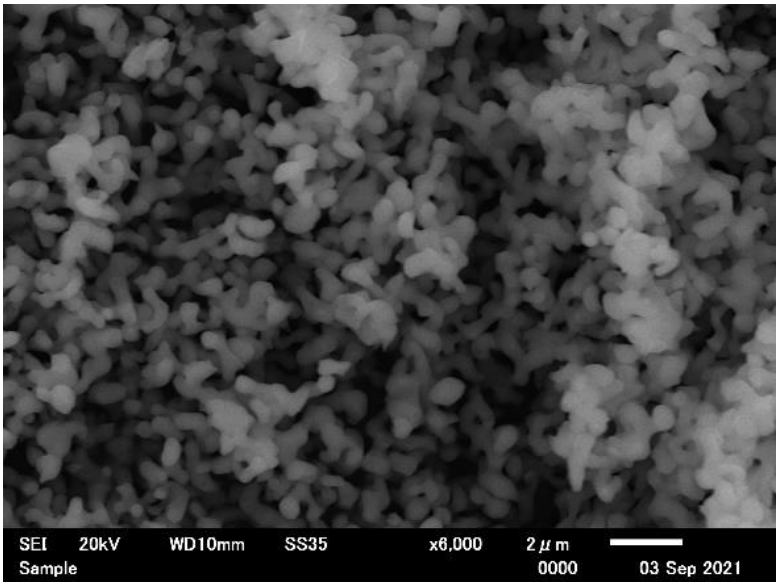


Figure S9: SEM micrographs of (a) Li^+ ions doped Zn_2SiO_4:Mn phosphor (b) Na^+ ions doped Zn_2SiO_4:Mn phosphor.



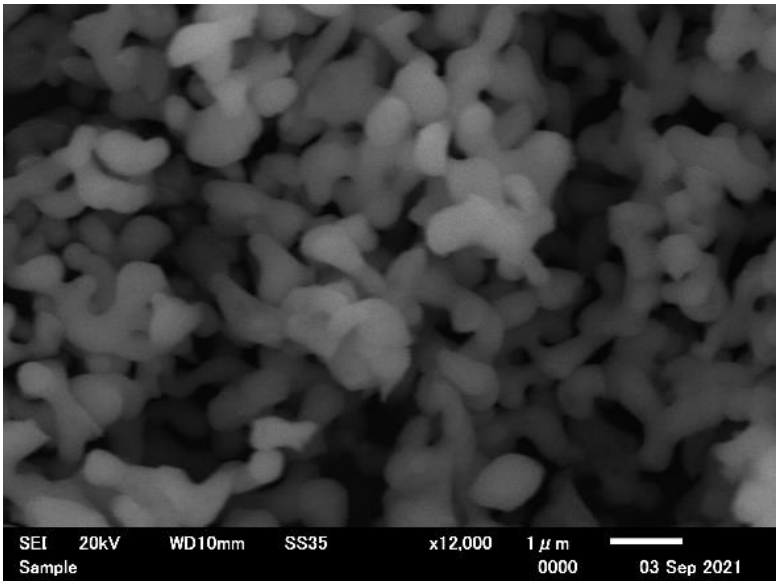


Figure S10: SEM micrographs of standard Zn_2SiO_4:Mn phosphor.

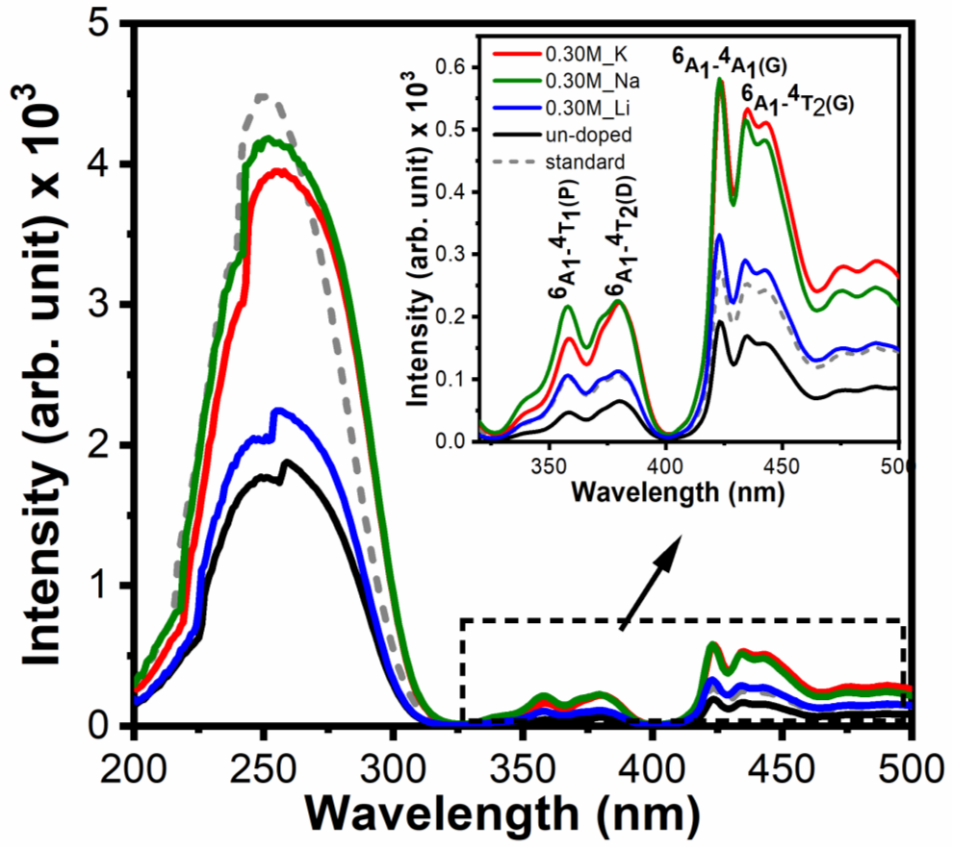


Figure S11: PLE spectrum for undoped and alkali metal ion (Li^+, Na^+, K^+) doped Zn_2SiO_4:Mn phosphor at doping concentration of 0.30M.

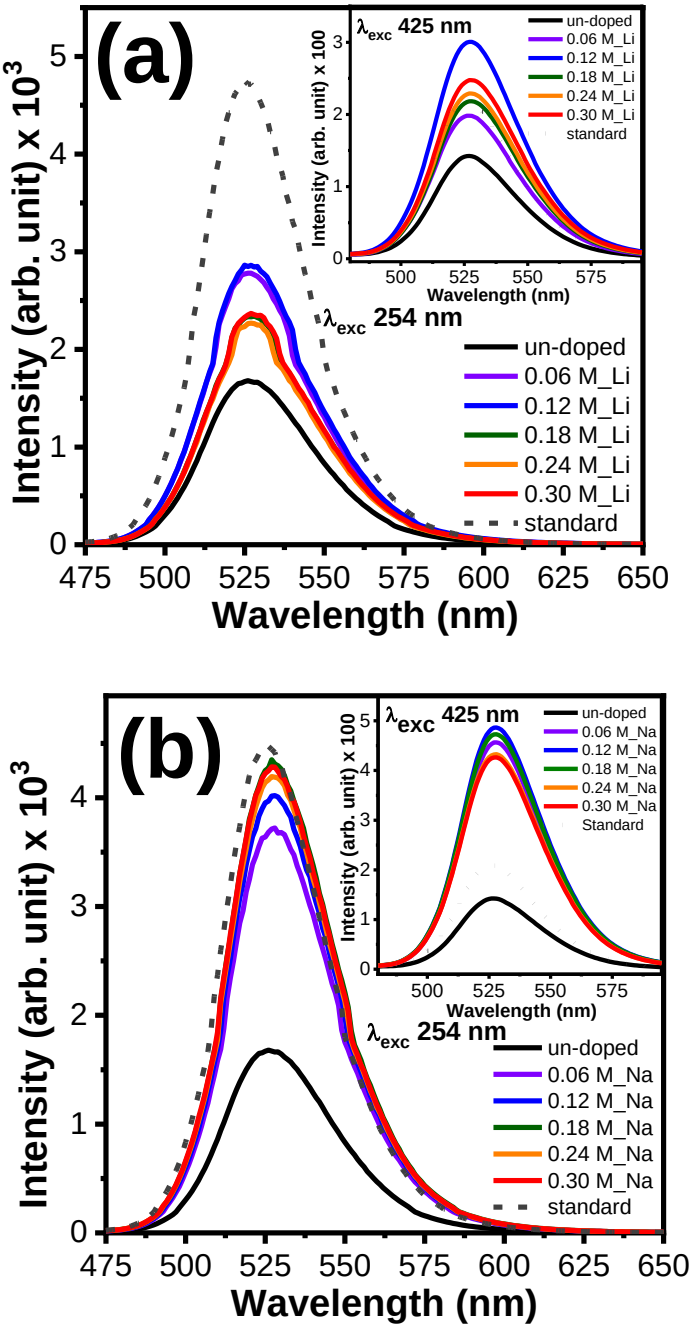


Figure S12: (a) PL emission spectra of (a) Li^+ ions doped Zn_2SiO_4:Mn phosphor, and (b) Na^+ ions doped Zn_2SiO_4:Mn phosphor, at λ_{exc} 254 nm, inset λ_{exc} 425 nm

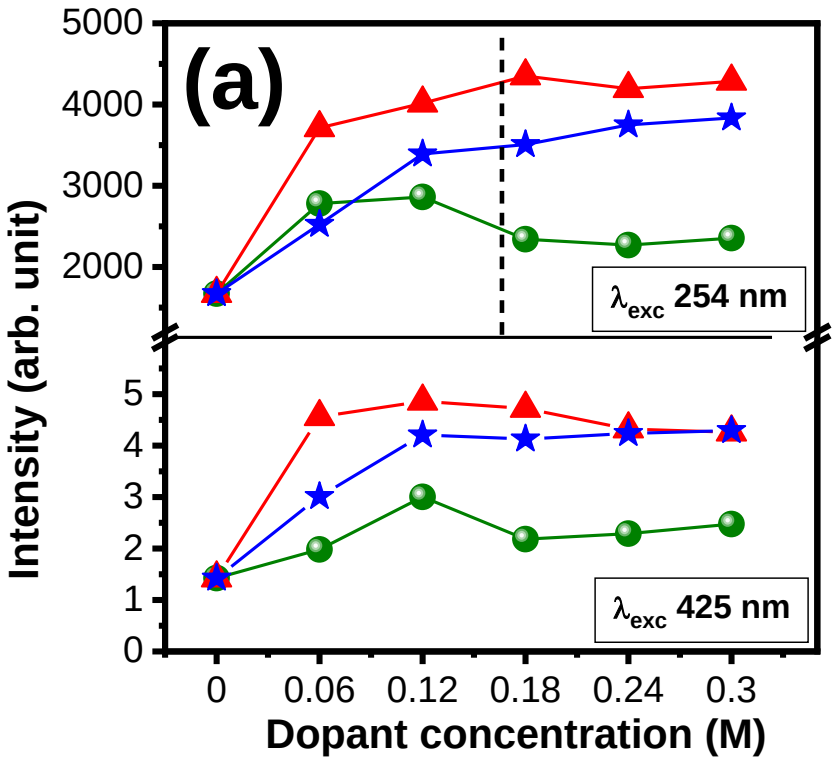


Figure S13: Dopant molar concentration dependence of PL emission intensities of Li^+, Na^+ and K^+ ions doped Zn_2SiO_4:Mn phosphor at excitation wavelength 254 nm and 425 nm.

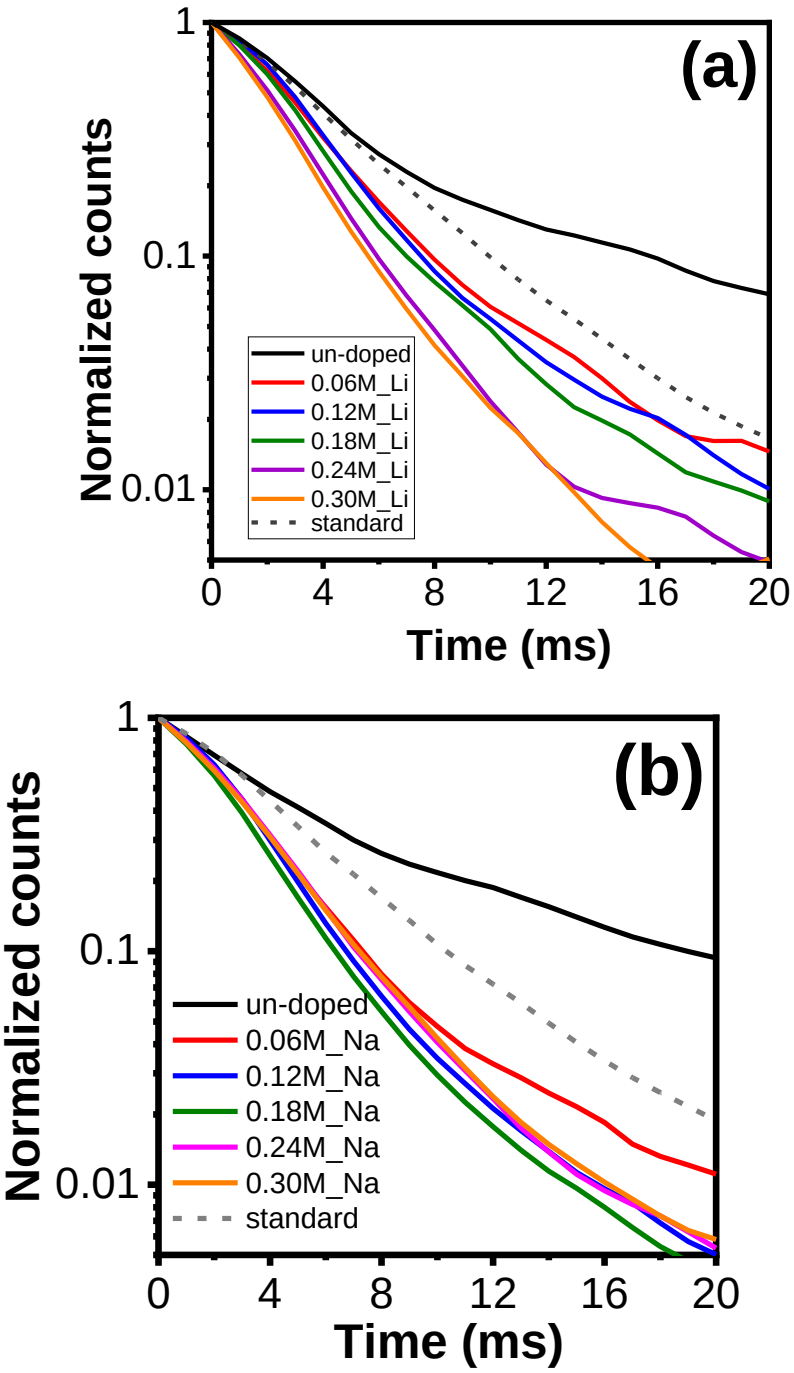


Figure S14: **(a)** Decay time profiles for un-doped, and Li^+ ions doped Zn_2SiO_4:Mn phosphor **(b)** Decay time profiles for un-doped, and Na^+ ions doped Zn_2SiO_4:Mn phosphor

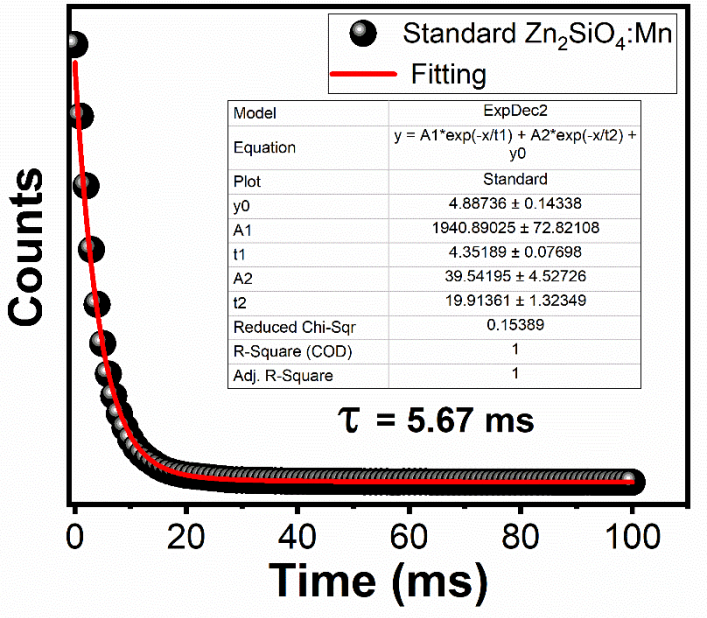


Fig. S15: Bi-exponential fitting of decay time profiles for standard Zn_2SiO_4:Mn phosphor.

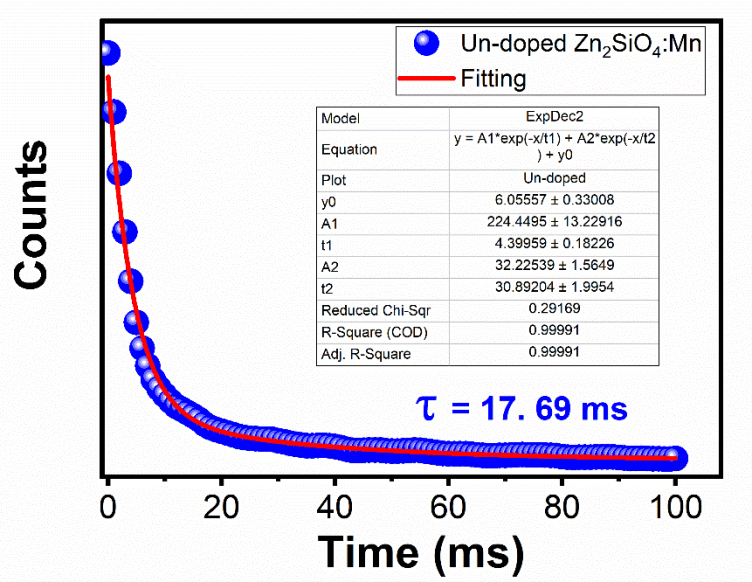


Figure S16: Bi-exponential fitting of decay time profiles for un-doped Zn_2SiO_4:Mn phosphor (synthesized in this work).

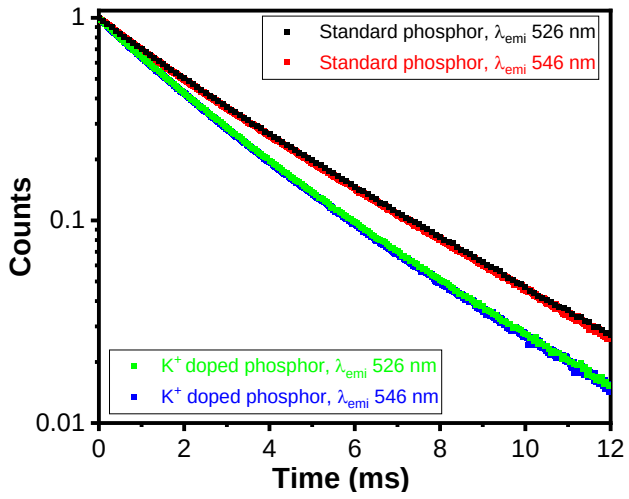


Figure S17: Decay time profiles of standard and K^+ ions doped Zn_2SiO_4:Mn phosphor measured for emission at 526 nm and 546 nm, respectively.

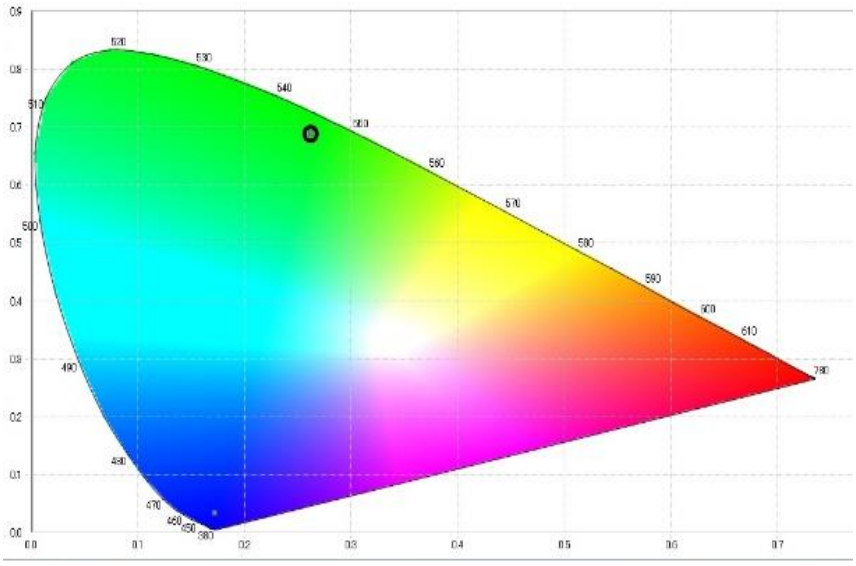


Figure S18: CIE diagram of 0.36M K^+ ions doped Zn_2SiO_4:Mn phosphor under 254 and 425 nm excitations. Typical CIE color coordinates of 0.36M K^+ ion doped Zn_2SiO_4:Mn phosphor are found to be (0.245, 0.697) under 254 nm excitation, in accordance with the commercial standard phosphor.

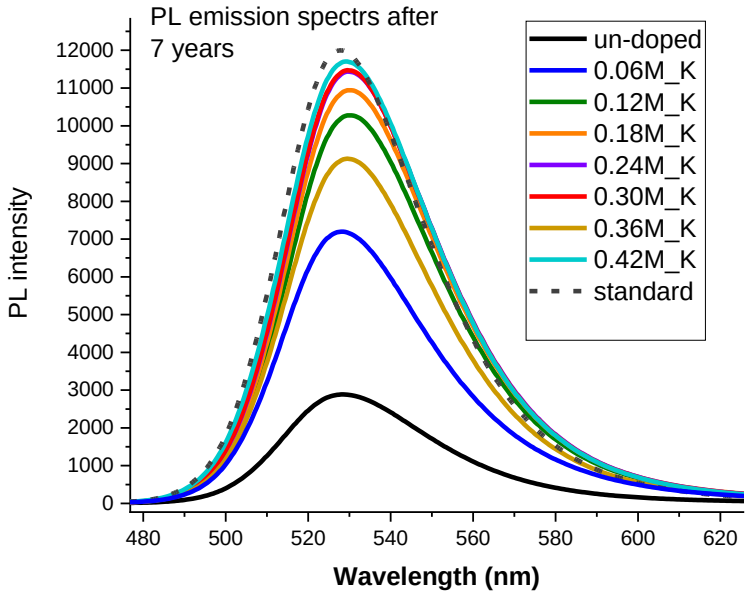


Figure S19: Comparison of PL emission intensities with respect to the standard phosphor after 7 years under 254 nm excitation.